MANAGING AIR QUALITY IN SANTIAGO: WHAT NEEDS TO BE DONE?

Raúl O'Ryan*
Alfredo del Valle**

ABSTRACT

This paper presents the bases for the design of a systemic management system for air quality in Santiago. The system proposed was developed through a novel participative methodology called Innovative Development, that required the participation of all the actors of the systems. As a result, an action map that provides a systematic and action-oriented view of what needs to be done to effectively manage Santiago's air quality at a general level has been developed. This map -constituted by 16 basic and 92 specific lines of action- distinguishes between established lines i.e., lines that the actors considered sufficiently managed, and non-established lines, where management, from an air quality perspective, is insufficient or non-existing. The basic messages delivered by the action map are that the established lines correspond chiefly to the system building effort undertaken between 1990 and 1994 focused on controlling "easily reducible" emissions, and improving the monitoring capacities; whereas management of the transport system, of key importance in reducing air pollution, and the remaining great themes –promotion of energy quality, management of the biophysical environment, socio-spatial management and education and communications– is scarcely initiated in Santiago. The current situation and propspects for each basic line of action have been reviewed, and a proposal is made about what needs to be done to manage the air quality system as a whole.

SINTESIS

Este trabajo presenta los fundamentos para el diseño de un sistema sistemático de administración de la calidad del aire en Santiago. El sistema propuesto fue desarrollado mediante una novedosa metodología participativa denominada Desarrollo Innovativo, que hace necesaria la participación de todos los actores de los sistemas. Como resultado, se ha desarrollado un mapa de acción que proporciona una visión sistemática y orientada a la acción en relación a lo que debe hacerse para manejar en forma eficaz la calidad del aire a nivel general. Este mapa –constituido por 16 líneas de acción básicas y 92 específicas– hace la diferencia entre líneas establecidas, vale decir, líneas que los actores consideran adecuadamente manejadas, y las líneas no establecidas, en que el manejo, desde una perspectiva de calidad de aire, es insuficiente o inexistente. Los mensajes básicos que aporta el mapa de acción son que las líneas establecidas corresponden fundamentalmente al esfuerzo llevado a cabo entre 1990 y 1994 por construir un sistema enfocado al control de las emisiones fácilmente reducibles y a mejorar las capacidades de monitoreo, mientras que el manejo del sistema de transporte, de importancia fundamental

* Center for Applied Economics, Department of Industrial Engineering, Universidad de Chile.
** The Innovative Development Institute.

para reducir la contaminación del aire, y los grandes temas restantes –promoción de la calidad de la energía, manejo del entorno y comunicaciones– todavía están en estado incipiente en Santiago. Se ha revisado la situación actual y las perspectivas para cada línea básica de acción y se formula una propuesta acerca de lo que debe hacerse para manejar el sistema de la calidad del aire como un todo.

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1. INTRODUCTION

This paper has been prepared in the context of a project, commissioned by the National Commission for the Environment (CONAMA), Metropolitan Region, which is aimed at to proposing bases for the design of a management system for air quality in Santiago. The project, in turn, is a part of a set of projects that are providing support to Metropolitan CONAMA in several matters, with financing from the Ministry of International Cooperation of the Netherlands.

The project has been conducted through a novel participative methodology, created by one of the authors and applied in several other fields, which is called Innovative Development (ID). It has had two main activities: a workshop with 25 participants, held in January 1995, and a series of consultations with a number of the workshop participants. This paper is based on both activities and owes most of its contents to these participants. But only the authors are responsible for its contents.

The paper starts by characterizing, in Section 2, the high complexity of the air quality situation of Santiago, that is to be managed by the system to be designed. It continues in Section 3 with an introductory presentation of the methodology applied, which is precisely addressed to managing complex systems. Section 4 presents the project's main output: the *action map* of Santiago's air quality. This ID instrument, made up by *lines of action*, provides a systematic and action-oriented view of what needs to be done in order to effectively manage Santiago's air quality, at a general level.

Section 5 comes next, reviewing for each basic line of action its current situation and prospects. Finally, section 6 presents the authors' view and proposal regarding what needs to be done in order to manage the air quality system as a

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whole. *This is not a proposal for creating an institution, but rather for starting a process*. In specific terms, it is proposed to undertake a wide participative process in Santiago in order discovering all the *potentialities* that the city may have for improving and maintaining at a good level the quality of its air. This proposal and its methodology make it possible to identify concrete and realistic actions, and simultaneously to build the consensus and the commitment that are required for implementing them effectively.

The paper's contribution can be synthesized as follows:

- It systematizes the set of tasks that should be undertaken to improve air quality in Santiago.
- It establishes the degree of progress to date in each of these tasks: Where do we stand today?
- It has done all this in a participative way, with the real actors, rather than as a specialists' view.
- It has begun to build a consensus on these tasks among the actors of air quality in Santiago.

It should be stressed that what is being proposed is not a set of specific measures, with costs and priorities. The authors believe strongly that it is not yet possible to make such proposals seriously given the high complexity of the managerial issues involved. This is rather a proposal about the way of undertaking the broad process, with multiple social actors, that is needed to design such measures so that they may be truly effective.

2. THE COMPLEXITY OF SANTIAGO'S AIR QUALITY SITUATION

In 1990 the recently created Special Commission for the Decontamination of the Metropolitan Region (CEDRM) initiated a significant effort to improve air quality in Santiago. It developed a "Master Plan"[1] that defined the policies and global actions that would permanently reduce emissions, ensuring compliance with the established air quality standards in the long run.

Some policies called for immediate action. For fixed point sources an emission concentration standard was established that forced most of the highest polluters to install control equipment or change fuels. Inspection of compliance was

[1] The plan also included a set of "immediate actions" to be carried out 24 months after the CEDRM was created, and one of "emergency actions" aimed at reducing emissions drastically but for a limited period of time, when unfavorable climatic conditions result in concentration levels dangerous for human health.

strengthened, in particular through the creation of the Program for Controling Emissions from Fixed Sources (PROCEFF) in 1993, in the Environmental Health Service. For mobile sources, almost 3,000 highly polluting buses -from an estimated total of 10,000- were withdrawn from circulation. New buses have been forced to comply with much tougher emission standards, in particular if they cross the downtown area. The circulation of buses through downtown has also been improved, by auctioning the right to circulate in this area. Within this auctioning process authorized bus lines were given incentives to increase the average capacity of the fleet (passengers/bus), reduce the average age of the fleet, have a number of vehicles appropriate for the required frequency, use a money collector separate from the driver,[2] and operate with low-emitting diesel buses. To monitor and enforce these measures an Enforcement Department was created in the Ministry of Transport.

Periodic technical inspections, that have been mandatory for years both for cars and buses, have been improved significantly in recent years. Much of the traffic light system has been automated and many street intersections have been improved. For domestic sources, open wood burning was prohibited in winter.

Moreover, actions with longer term effects were also initiated. For fixed point sources, an attempt to "freeze" total emissions to the level emitted in 1992 was made by requiring that new sources offset their emissions through a "compensation system" to be described later on. New area sources have been required to comply with a relatively tough emission standard, resulting in the use of cleaner technologies and fuels. For new vehicles, emission standards that require -at least- the use of catalytic converters went into effect in September 1992. Unitary vehicle emissions of new cars are now drastically lower than before 1992. The subway system is being extended, adding a new line that will serve a highly populated area.

In consequence, Santiago's air quality seems to have improved over the last five years. The number of pre-emergency and emergency episodes has declined steadily over the period, from 13 in 1990 to 4 in 1995. The levels of particulate matter smaller than 2.5 microns (PM-2.5), that have significant health effects, are declining. This is no minor result considering that the trend was towards an explosive increment in emissions due to the uncontrolled nature of the system.

However Santiago's air quality is a complex problem, and as the Hydra it has many heads. It is far from complying with the air quality standards for both particulate matter and ozone. According to recent monitoring results, concentrations of PM-2.5 have been falling; however, concentrations of larger particulates have increased. The rate of reduction obtained for particulates is not the one required to reach the desired quality standard. The ozone standard is violated over 30 percent

[2] This requirement, however, has not been implemented.

of the time in the city and Santiago was recently been declared in non-compliance for this substance. Notwithstanding, it is expected that within a few years the use of natural gas -important potential source of NO_x, precursor of ozone- will increase significantly making the ozone problem worse. New problems have surfaced, such as pollution by sulphates and polycyclic aromatic hydrocarbons (PAH). Furthermore, the compensation system has not been implemented yet.

In summary, the actions undertaken up to the moment have been basically geared to reducing emission factors. What is not at all clear, however, from a management perspective, is the degree of consolidation and permanence of these activities over time. Moreover, it is equally unclear what the *complete* scope of additional actions are which might ensure that the city meets its air quality standards. There is no coherent plan for the city that incorporates air quality in many of the decisions that affect it: construction of new roads, housing projects, transport system, urban development plans, energy use. In the absence of such measures, there is no assurance that air quality will not revert as the city grows in extension, the demand for trips grows, and the circulation of cars increases. For transport, a recent study suggests that "the rate at which the problems are solved or reduced is generally lower to the rate at which they are created or exacerbated" (CEPAL, 1995).

A multiplicity of high level institutions participated in the action lines established for the system in 1992. These include the Environmental Health Service, CEDRM, Mining Ministry, Economics Ministry, CONAMA, Ministry of Agriculture, Transportation Ministry, Commission of Urban Transport, 34 Municipalities, the Regional Government, Housing and Urban Development Ministry, Superintendency of Electricity and Fuel, National Petroleum Enterprise, National Energy Commission and the Ministry of Education.

Effective management requires a powerful coordinating body capable of generating and promoting continuous actions by these institutions. Moreover it must be able to evaluate the effects of actions in each line on air quality. Unfortunately the CEDRM, currently CONAMA Metropolitan Region, has only a handful of lawyers, engineers and other professionals. With the scarce resources available it must take care of a diversity of environmental problems, ranging from air and water quality to solid waste management. Moreover, its scope includes the whole region, and not only the city of Santiago. As a result it has been forced to concentrate its actions in promoting the reduction of particulate matter and carbon monoxide emissions. Ozone problems have not been tackled yet and local SO_x problems only for emissions from highly contaminating sources.

Evaluating the results of the activities undertaken and of the possible effect on air quality of various strategic plans and options has only been done in a preliminary form (see for example Intendencia 1990, pp. 57-135). There is no continuous activity in this direction. Moreover, the dispersion models required for such an

activity are cumbersome to operate and improvements in the monitoring system and inventories are required before adequate assessments or predictions can be made.

Finally, there are many examples of "trial and error" projects that were initiated and did not give the desired results or that were discontinued over time. Trolleybuses were common in Santiago until 1978 when they were dismantled. In 1992 two private lines that crossed the downtown area were initiated, promising that in the near future 300 buses for a total investment of US$ 60 million, would be in operation. Two years later, the trolley system filed for bankruptcy and left a debt of US$1.5 million. Testing of less contaminating bus technologies have been proposed, however in many cases not carried out. Bicycle paths and parking have also been constructed only to be left in disuse and disrepair. Bus fare collectors have been proposed in the auctioning system, and even used in some lines, only to disappear. Restrictions to the circulation of 20 percent of cars, an action meant to be for emergencies, has become permanent and goes on for 9 months each year. In 1987 a project for a funicular in downtown was the main news in an important newspaper [El Mercurio, February 23, 1987]. Many of these projects would be of interest, however their failure results in a negative "stigma" that makes them not "politically correct" and thus they disappear from the public discussion.

In conclusion, Santiago's air quality can be considered a "messy" or highly complex problem with an ever increasing number of issues, large number of participating institutions with objectives different than clean air, and a multitude of disciplines, from medical to engineering, economics and law.

3. MANAGING COMPLEXITY: A PARTICIPATIVE METHODOLOGY

The following presentation of the "Innovative Development" (ID) methodology will be minimal and schematic. It will show only the elements which explain why and how it works. The reader is referred to Del Valle (1992), from which most of this chapter's text is excerpted, and also to Del Valle (1993), for further details.

It should be borne in mind that this is a social systems or process methodology, rather than an analytical one. Its outputs are concrete effects on social processes, rather than pieces of information. For readers non familiar with the social systems way of thinking,[3] it is suggested to look first into the outputs presented in the following chapters, which are self-contained, and then to review this one.

[3] A comprehensive overview of social systems thinking is provided in Choukroun and Snow (1992), a *festschrift* in honor of Russell L. Ackoff. Ackoff is one of the key exponents of this paradigm, along with Churchmann, Trist, Emery, Beer, Ozbekhan and others.

3.1. The nature and management of social complexity

Santiago's air quality situation is a typically problematic, complex or "messy" one[4]. Some common characteristics that people usually observe and especially feel in complex situations like this are:

- Infinity of themes: More every day.
- Infinity of related institutions: More every day.
- All disciplines apply and it is difficult to know which one to start from.
- A feeling that others are simplifying the problems.
- Feelings of agreements and disagreements.
- Difficulties in communication: Are we talking about the same thing?
- Even greater difficulties for acting: There seems to be more going back than going forward.
- Everything seems to be related to everything: Where is the thread?
- Some usual tactics help little: experiments, trial and error, starting at a part of the problem, setting priorities.
- Resorting to analysis seems to amplify each one of the above characteristics.

Complexity is a characteristic of social reality which, in ID's view, cannot be faced effectively with the usual tools available, namely, analytical work and empirical work. The following paragraphs will provide an introduction to ID's particular approach to this issue.

Complexity will be understood here as *an output of an observation process* rather than an objective property of some thing observed. Judging that something is complex means that the observer's description instrument does not have the capacity to give an adequate account[5] of the thing observed. For instance, if a regular user opens the computer on which he is typing a text, he will find it overly

[4] Ackoff gives, in the sense shown, a technical meaning to the term "mess", and includes the "formulation of the mess" as one of his methodological steps (Ackoff, 1981, Chapter four). ID's procedure for this purpose is different.

[5] The term "account" rather than "explanation" is used here, since the concern is with conceptual frameworks rather than with theories.

complex, for lack of command of the knowledge necessary to describe it; but a computer specialist may probably find it simple. Similarly, the movement of the solar system was regarded as highly complex when it was described through the Ptolemaic apparatus; but it became surprisingly simple once the Copernican theory was available and any layman could reproduce the description.

In both examples an *observer* utilizes some *conceptual framework* to give account of an *observed thing*. The framework may or may not have the capacity to give the observer an adequate account of that thing. And we judge *complex* the situation in which the framework falls short of the task. Bearing this in mind, a general question may be asked: Is there any criterion for deciding under what conditions the account will be adequate or inadequate? In other words, Is there any general measure of complexity that may be applicable to both the thing and the framework?

Such a criterion does indeed exist, and is provided by the fundamental work on complexity contained in Ross Ashby's "Law of Requisite Variety". Ashby specified as a measure of complexity the notion of *variety*, which is the number of distinguishable states that a system can show (Ashby, 1956, p. 130). It is reasonable to expect that complex systems will generate large varieties through their behavior. What is to be noticed, however, is that they do so and yet keep their essential variables within their particular limits (e.g. physiological limits in an organism, population sizes in an ecosystem, performance variables in a business firm, etc.). The key question is: What could prevent these systems from being in any other of their possible states, i.e., from generating unending variety? Ashby found the answer to this question to be in variety itself: it is some other variety that is "absorbing" the variety of the system in a process called *regulation*.[6] His statement is stronger: "Only variety can destroy variety" (Ibid., p. 135).

Coming back to conceptual frameworks, if somebody judges that some particular social situation is complex, he is in fact acknowledging that he has available a conceptual framework through which he can generate a smaller variety than the one he is actually observing. Such a judgement means something else: it means that the situation is not only beyond his understanding, but also beyond his control. If he wanted to use his framework for *managing the situation* he would find it not manageable. From this we can observe that manageability of any complex system can be obtained through two ways, or a combination of them:

- Reducing the variety of the managed system (e.g., jailing a criminal); or

[6] In ecosystems, for instance, the populations of some species are kept in check by the populations of others who prey on them; and the predator populations are also kept in check by the prey ones via food availability. If this were not the case the system's particular limits would not exist: some populations would grow indefinitely and others would become extinct.

- Increasing the variety of the managing system (e.g., hiring an expert).

We will introduce now the "action map", the main instrument of ID, and show that it is an instrument that may be used for management purposes in both ways.

3.2. Lines of action and action maps: A specification

We call *line of action* a particular way of observing reality. It is a system of human activities which are to be performed with some degree of permanence by one or more actors, with the purpose of attaining one or more objectives, and which is clearly identified in practice by the actors and other observers to whom these objectives are relevant. A line of action is, in other words, a *social system* that is apprehended as a unity and has three types of components: *activities*, *actors* and *objectives*. When a line of action is identified, its social and bio-physical *environment* is identified as well, though it may be kept implicit.

Lines of action may or may not be currently *established* in the real world, through actors effectively carrying out activities, since the specification is also applicable to action under consideration. Actors and other observers give *names* to the lines of action they are interested in, to identify them and to communicate about them in real life. The existence, in a particular domain, of a commonly accepted name to refer to "what is being done" or to "what could be done" is a good indicator of the presence of a line of action. The identification of a line of action and its environment in the real world is not guided by any theory -either social or natural- but only by practice. It is guided by action-oriented distinctions rather than by analytical distinctions.

Lines of action normally present themselves as groups of parallel lines. They have two general properties:

- Every line of action is made of more particular lines of action.[7]
- Lines of action involve both actual and potential actors, activities and objectives.

The first property makes it possible to use this concept at any level in the social system being dealt with, and to apply the same methodology regardless of the location of the line in the system. The second one makes the connection with the crucial theme of *innovation*, to be discussed on the following section, by means of another key notion of ID: the notion of *potentiality*. Potentialities are expected or possible results of actions which a social system could undertake under its particular

[7] This property is called *recursiveness*.

environmental conditions, that might improve its capacity to attain its higher objectives. The mentioned connection is double: (a) in principle, any potentiality may be the basis for establishing a new line of action, or innovating; and (b) in principle, every well-specified line of action presents potentialities.

The ordered set of names given to the lines of action of a social system is called in ID the *action map* of that system. The reader is referred to the following chapter, in which the action map of air quality management in Santiago is shown. An action map may consist of any number of levels of generality (or particularity) in the presentation of the system, though in practice two levels are sufficient.[8] The action map provides a particular kind of representation of a social system: it shows what it is doing at present, as well as what it could do in the future. It gives at a glance a direct image of the system's action, by showing actual and potential activities and actors. This is a different kind of representation from the usual ones, which are made in economic or technical languages, and is a complement to them.

3.3. Participation and innovation: Handling social complexity

Innovation is, naturally, the crucial topic of ID. This is a process of deliberate change that is undertaken only by some social systems[9]. Innovation is the process through which a potentiality is materialized in a system, and becomes an established line of action. This process is described in ID as a positive feedback cycle that may start when a potentiality is identified or known by somebody, and has the following components: (1) raising awareness of the potentiality, (2) motivation towards organizational change, (3) organization for performing new operations, (4) executing the new operations, and (5) producing new results which demonstrate the potentiality. The last one closes the cycle, since it is concrete results what actually generates awareness in the real world.[10]

The specific contribution of ID consists in making possible the systematic promotion of innovations in complex settings. This is done by means of participative processes. As has been shown through extensive professional practice[11], lines of action and action maps lend themselves to be used in participative contexts. Being action representations, they are understood intuitively by the real actors of the social systems being dealt with. Moreover, they may be applied effectively for the generation of consensus among different actors in a variety of situations.

[8] Lines of action are called "basic" at the general level of the map and "specific" at the particular level. The former are identified through letters A, B, C, ..., and the latter through letters and numbers: A-1, J-3, ..., etc.

[9] Systems that simply react to external pressures are adapting passively, rather than innovating. In ID's view, successive adaptations give rise to evolution. Only successive innovations give rise to development.

[10] The inovation process has deep effects on the social system that undertakes it, going all the way into the system's culture. Such effects will not be discussed here.

[11] See Del Valle (1993) for some experiences up to 1992. Subsequent work has been done on regional development, traffic safety, housing policy and other fields, in addition to air quality management which is reported herewith.

From the above description and from an inspection of next chapter's action map, it is not difficult to realize that the action map is a highly effective instrument for dealing with social complexity through participation. Its variety-handling capacity is very large for the following reasons:

- It is built directly by the actors, in their own language.
- Recursiveness allows it to focus on any desired degree of generality or particularity in the system under inquiry.
- The consideration of potential actions allows it to be free from the rigidities of the present (e.g., "this is done this way").
- It does not attempt any formal modelling of social systems, but just a mapping of their components under the guidance of a logic of action.
- Its variety-handling capacities are not limited by the linguistic distinctions of any particular discipline.
- It is able to combine the variety-handling capacities of a number of disciplines, by providing them with a common ground, i.e., action.
- It involves a control device, through participation in the map's formulation or validation.

3.4. The methodological steps of Innovative Development

This presentation of ID will now be completed with a brief description of its four methodological steps. They are:

Formulation of the action map: Systematic determination of the whole space of current action and potential action of the social system. It may be formulated participatively, by the actors themselves conducted by an animator[12], or through research work validated with the real actors. The way followed in the air quality case was the participative one.

Diagnosis of development and maturity: Assessment of the distance of the social system to its attainable future and of its capabilities to create such a future. This is done by identifying its established and non-established lines of action, evaluating its knowledge of potentialities and doing related evaluative work. In the air quality case the diagnostic exercise of the initial workshop showed that only 5

[12] In ID jargon, an *animator* is a facilitator fully qualified and experienced in this methodology.

of the 16 general lines of action are presently established, and only 23 of the 76 specific ones are in the same condition [see the action map's key].

Study of potentialities: Identification and evaluation of the potentialities that each line of action of the system may have, for strengthening existing lines of action or for generating new ones. This step allows the social system to find its own concrete prospects for self-sustainable action.[13]

Design for action: For valuable potentialities: formulation of concrete objectives, specific activities and applicable organizational mechanisms for establishing the corresponding innovations in practice. This is the step in which the innovations materialize, through the actors who make use of the potentialities available.

4. AN ACTION MAP FOR SANTIAGO'S AIR QUALITY

4.1. The action map's formulation

The action map for Santiago's air quality that is presented in this chapter was formulated initially by a Workshop held in Pirque, near Santiago, on 25 and 26 January, 1995. The Workshop was convened by the Intendente Regional of the Metropolitan Region of Santiago and the Mayor of Santiago, in his capacity as Chairman of the Coordinating Council of Mayors of Santiago.[14] The 25 Participants in the Workshop included Regional Ministerial Secretaries, the Director of Conama R.M., representatives from Ministries and Municipalities, environmental consultants and researchers, and representatives from NGO's among others.

The map prepared by the Workshop was subsequently revised on technical details by the authors and two consultants who had participated in it,[15] in order to improve its consistency and practical usefulness. The revision adhered strictly to the

[13] The notion of potentiality was introduced in section 2 of this chapter. In project "Magallanes creates its future" (Del Valle, comp., 1994), 260 people became active participants in an exercise for identifying potentialities, which was organized in 14 interactive working groups: one per basic line of the action map. They found 165 potentialities, involving 15 consensus mechanisms, 18 socio-cultural innovations, 22 projects to manage the region's touristic heritage, 35 promotion mechanisms, 40 private investment projects, 20 public investment projects and 15 research and development projects. In the participative application of ID in Chile's National Policy for Traffic Safety, 129 potentialities were identified by 208 participants in 9 interactive working groups (Comisión Nacional de Seguridad de Tránsito, 1995).

[14] The city of Santiago, with 5 million inhabitants, has three forms of government acting upon it: (1) the central government, which frequently promotes initiatives for the city at the Ministerial level; (2) a regional government, headed by an Intendente Regional appointed by the President of the Republic, which has jurisdiction over the "Metropolitan Region", to which Santiago belongs; and (3) 32 municipal governments headed by their respective Mayors, who are autonomous and elected directly. There is a Municipality of Santiago, which only has jurisdiction over the center of the city. The Coordinating Council of Mayors is a body with no formal authority.

[15] Mr. Juan Escudero, former Executive Secretary of the Special Commission for Decontamination of the Metropolitan Region, and Mr. Luis Larraguibel.

consensus achieved, and was described in detail to the participants in the Workshop report. As a side product of this revision, a more detailed action map for line M, "Transport System", was also prepared; it is presented in the following chapter when the corresponding line of action is dicussed. The final version of the map is presented in the next page.

4.2. What does the action map say?

An action map generated participatively shows, in general, everything that needs to be done in the social system delimited by its name, in order to attain the strategic objectives of that system. All this is no abstract theory, personal idea or similar source of inspiration. It is an expression of consensus of the only ones who legitimately may state it: the social actors of that system, who are the ones who can build such a future. What it shows, in other words, is *a consensual vision of future for that social system*.

The map shows something else, which is of a great practical significance: how much progress has been made towards building such a future and how much is still to be done. The action map is, therefore, an instrument that in addition to a vision of future shows a *consensual diagnosis of progress* and a *consensual program of action* for the social system.

On these bases, it is possible to synthesize as follows the basic messages delivered by this action map:

- The scope of action that must be covered to achieve effective management of Santiago's air quality is extremely wide, since it comprises 16 basic and 92 specific lines of action. The map has been ordered so that the lines directly related to emissions are shown on the left and center columns, and those accounting for other factors are shown on the right-hand column.

- Of those 16 basic lines there are currently 5 established, whose names are capitalized on the map, and 11 non-established. At the level of the specific ones, 36 have been established and 56 have not yet been so. It is, therefore, a management system that is only partially built, and which is still far from being completed.

- The established basic lines correspond chiefly to the system building effort undertaken by the Special Commission for Decontamination of the Metropolitan Region between 1990 and 1994. This effort was focussed on the control of emissions, including the monitoring and the norms that made it possible, and on the management of emergencies.

- There are also some specific lines established which do not belong to the mentioned basic ones, but which are likewise in the area of emission control, such as Inventorying of Street Dust Emissions (E-1), Paving (E-3), Operating Standards for Pesticides (H-2) and a few others. The Workshop agreed that in these cases the corresponding basic lines can still not be regarded as established.

- The other set of established specific lines that is noticeable for its number is naturally the Transport System (M). There are three very significant lines that are established: Structuring and Access Roads (M-1), Rapid Mass Transit System (M-3) and Bus System (M-4). Notwithstanding its number and significance, the Workshop did not hesitate in rating line of action M as non-established: Santiago does not have a unified vision of its transpoort system; it only has available partial visions, which refer to some of its components.

- The treatment of the remaining great themes of air quality is scarcely initiated in Santiago. Nothing consistent is being done on the Promotion of Energy Quality (L). Only two lines are established regarding the Bio-Physical Environment (N). There are three established lines in Socio-Spatial Management (O), with six others still to be established. And only two out of six lines are established in Education and Communications (P).

5. LINES OF ACTION: CURRENT SITUATION AND PROSPECTS

This chapter presents the diagnosis of the degree of development of Santiago's air quality management system that has been carried out in this project. For this purpose, the following four topics are reviewed for each basic line of action:

- **Institutional capacity**: Which actors have management mandates in this line?, What is the scope of the mandate?, By using what instruments?

- **Technical capacity**: What teams does it have available to apply such instruments?

- **Innovation processes**: What innovations are under study or being implemented in this line of action?, In what development stage are they?

- **Evaluation**: What is the authors' judgement, based on the interviews made, about the degree of development of each line of action?

As may be expected, these questions could not be answered in all cases. However, the results obtained are a very good approximation that gives useful insights about the management situation of each line of action.

Action map: (*)

A MANAGEMENT SYSTEM FOR AIR QUALITY IN SANTIAGO

Key: UPPER CASE - established line of action
lower case: - non-established line of action

A MONITORING AND EPIDEMIOLOGICAL SURVEILLANCE
- A-1 AIR QUALITY MONITORING
- A-2 EPIDEMIOLOGICAL SURVEILLANCE
- A-3 Effects on flora and fauna
- A-4 Effects on materials
- A-5 METEOROLOGICAL MONITORING
- A-6 MODELING

B QUALITY STANDARDS
- B-1 CRITERIA POLLUTANT STANDARDS
- B-2 Standards for other pollutants

C STATIONARY SOURCE EMISSIONS CONTROL
- C-1 EMISSIONS INVENTORY
- C-2 EMISSION STANDARDS
- C-3 ENFORCEMENT
- C-4 Low and zero emission technologies
- C-5 GRAVEL AND SAND PRODUCTION CONTROL
- C-6 Control of remote sources
- C-7 EFFICIENT BOILER OPERATION
- C-8 Participative enforcement
- C-9 Specific economic instruments

D MOBILE SOURCE EMISSIONS CONTROL
- D-1 EMISSIONS INVENTORY
- D-2 EMISSION STANDARDS
- D-3 RESTRICTION TO CIRCULATION
- D-4 ENFORCEMENT
- D-5 Low and zero emission technologies
- D-6 Vehicle driving and maintenance
- D-7 TECHNICAL INSPECTION
- D-8 PARTICIPATIVE ENFORCEMENT
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E Street dust emissions control
- E-1 EMISSIONS INVENTORY
- E-2 Management standards
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F Transient source emissions control
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G Domestic source emissions control
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- G-3 Enforcement
- G-4 PROMOTION OF CLEAN TECHNOLOGIES
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H Agricultural emissions control
- H-1 Emissions inventory
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I Technical support for measurements and certification
- I-1 STATIONARY SOURCE EMISSIONS MEASUREMENT
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J Non-regulated pollutants
- J-1 Control of air toxics
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K EPISODE CONTROL
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L Promotion of energy quality
- L-1 Fuel quality
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M Transport system
- M-1 STRUCTURING AND ACCESS ROADS
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N Management of the bio-physical environment
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O Socio-spatial management
- O-1 Impact assessment of public road construction
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- O-4 Development of sub-centers
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- O-6 INDUSTRIAL LOCATION
- O-7 Policies for population distribution in Chile
- O-8 Policies on social segregation
- O-9 DENSIFICATION PROGRAMS

P Education and comunications
- P-1 Formal environmental education
- P-2 NON-FORMAL ENVIRONMENTAL EDUCATION
- P-3 Technical dissemination
- P-4 Motivational comunication
- P-5 INFORMATIVE COMUNICATION
- P-6 Training of journalists

(*) METHODOLOGICAL NOTE: The "action map" is an instrument used to describe complex social systems through their action. It shows at the same time what the system is (present) and what it could be (future). It is a tool of the "Innovative Development" methodology, used in this Project.

Map developed by: An Innovative Development Workshop, with participants representing all social actors linked to air quality in Santiago, held in Pirque on January 25 and 26, 1995. Subsequently revised for consistency by the Project team.

This Action Map belongs to a project report with the same title as the map, by Dr. Alfredo del Valle (The Innovative Development Institute, Santiago, Chile) and Dr. Radi O'Ryan (Department of Industrial Engineering, Universidad de Chile). Santiago, Chile, September 1995.

A. Monitoring and epidemiological surveillance

This line of action was considered established in the Workshop. During the personal interviewing stage however it was determined that the specific line for epidemiological monitoring, was reverting to non-established. The epidemiological monitoring, undertaken by the EHS, provides the feedback mechanism to evaluate the performance of all the actions towards improving the air quality; it is the benchmark for the decontamination plans. Its loss of effectiveness originates in financial problems, a situation that also influences negatively another specific line: Meteorological monitoring, which plays an important role in the detection of circumstances that favor contamination episodes.

Monitoring meteorological conditions with the objective of dispersion modelling and episode prediction, was one of the first activities undertaken by CEDRM when it was created in 1990. CONAMA R.M. is currently in charge and the expected evolution towards predictive power and modeling of relevant atmospheric phenomena (AIRVIRO) is under way and it may be considered the main area of innovation in this area. There are several programs with international support achieving results and technology transfer.

In conclusion, dynamics for this line currently points to further development in modeling and predictive capacity and to a relative stagnation in the monitoring areas.

The monitoring of air quality, according to a recent evaluation by German experts, is carried out by highly motivated personnel with outdated equipment and inadequate hardware and information systems. The effects of air contamination on materials, flora and fauna are not considered in the plans and policies of the line; there are no institutions in charge of this problem.

Tasks such as restoring the effectiveness of epidemiological surveillance and the renewal of the equipment and systems involved in air quality monitoring appear as crucial for the line. Assessing contamination impact on non-human organisms will eventually be required.

B. Quality standards

The main objective of this line is the development of air quality standards, and their periodical updating. The Environmental Framework Law has given these standards a key role for the development of environmental policy: if a zone exceeds a standard, then a decontamination plan must be developed and implemented. Thus an air quality standard is required to trigger action by the regulator, requiring

reductions of emissions[16]. The institutional support for this line is given by CONAMA R.M. (formerly CEDRM) in joint action with the sectoral Ministries of Mining (MINMIN), of Public Health (MINSAL) and of Agriculture (AGRIMIN). It is definitely an established action line with sound institutional and financial backing.

Until now the action has been directed to criteria contaminants (TSP, PM-10, CO, SO_2, O_3 and NO_2) but the actors are aware that their future efforts will have to be oriented to the development of standards for other contaminants, in particular toxic substances such as sulfates, mercury, asbestos, arsenic and lead.

C. Stationary source emissions control

This is an established line of action. On April, 1990 the CEDRM (Special Commission for Decontamination of the Metropolitan Region) was created and this action line was one of its priorities. The objective was to control and reduce emissions from stationary non-domestic sources. Emission standards for stationary sources were specified by the DL 4 (Law Decree), issued in 1991, which also prescribed the operation of an emission compensation system in order to make compliance more flexible. In 1993 SESMA (Environmental Health Service) took charge of the emissions inventory, emissions standards and enforcement by creating an executive branch: PROCEFF (Stationary Sources Emission Control Program) . SESMA had also been, for a long time, in charge of boiler operation supervision and MOP (Ministry of Public Works) controls the extraction of building materials at the river fronts, but in both instances their actions pursue security objectives unrelated to air quality. Consequently, there are clearly identifiable institutions that carry out the basic operations required.

The financial resources to support the operation of this action line are budgeted as a standard item in the MINSAL (Ministry of Public Health) budget for the Metropolitan Region.

This institutional setting has accomplished:

- A sizable reduction in the emissions of particulates issued by highly contaminating sources,
- an improvement in the emissions inventory, and
- a substantial increase in the enforcement capacity.

The line of action for specific economic instruments exhibits one activity, namely the compensation system for particulate emission. Under this system current

[16] Emission standards can also be used to trigger such actions.

sources that reduce more than required by their individual goals -established through an emission standard- can sell the difference to other sources, current or new, wanting to reduce less than required by their specific goals. It should be said that this system has not been implemented yet, and as a result the addition of new sources is not under control.

Nonetheless there are numerous potentialities identified in this study which are not carried out as the innovation capacity exhibited by the specific action lines is scarce. Systematic potentialities research is lacking in:

- Particulate characterization,
- expansion of the inventories to cover other substances,
- standards for contaminants other than particulates,
- continuous monitoring for selected sources, when warranted,
- linking boiler operation supervision and extraction of building materials to air quality,
- extending the scope of the economic incentives (NOx, COV's), and
- implementation of the marketable permits system.

Unexplored potentialities or absence of systematic action in non-established specific lines were detected in the following areas:

- Low emission technologies,
- control of remote sources, and
- participative enforcement.

In conclusion this action line has accomplished its objectives with regards to reducing the explosive growth in emissions of particulates, potentialities have been identified, and there are resources available to take advantage of them. It is necessary to make progress in measures that permit reducing current emission levels of particulates and regulate other substances, such as No_x, hydrocarbons, etc.

D. Mobile sources emissions control

Established action line whose institutional support rests on CONAMA R.M. and MINTRATEL. CONAMA R.M. is in charge of the emissions inventory and, in its former state as CEDRM, provided technical and financial assistance for the development of emissions standards which nowadays conform the basic elements in the control performed by MINTRATEL. Police forces supply the "muscle power" for enforcement since the Ministry officials lack the legal attributions for it.

The line exhibits important achievements directly related to air quality improvements such as:

- Regulations (in effect since Sept. 1, 1992) requiring that in Santiago all new passenger cars, taxis and light-duty trucks meet EPA 1983 standards (controlled). To meet these stringent exhaust emissions standards, these new vehicles include three-way catalytic converters and electronically controlled fuel injection systems. The necessary implementation of the infrastructure for unleaded gasoline distribution was phased in smoothly.

- All new urban buses in Santiago must meet EPA 1991 heavy-duty vehicle exhaust emissions standard. The natural extension to heavy-duty diesel trucks awaits for the development of a standard test duty cycle.

- The establishment of a mandatory technical checkup schedule for all vehicles along with spotchecks and a regulatory organism (Technical Center at Maipú) to reduce corruption since the revision plants are licensed to private operators.

- Registration of new vehicles -cars and light-duty trucks-, where MINTRATEL is involved in the approval for their internment using a pre-existing list containing the model identification.

Given the wide scope of activities, one would expect the detection of a sizable number of innovation potentialities either identified or in operation. Unfortunately this is not the case; there has been a loss in the initial momentum transmitted by CEDRM. Up to now, adopting the new technologies developed in other contexts has proved successful in reducing emissions. The horizon for further improvement appears limited; no technological *deus-ex-machina* is in sight.

Innovation potentialities appear limited in some key areas. Important potentialities such as the development of sound driving and vehicle maintenance practices; the introduction of new low or zero emission technologies; and pilot programs to test alternative fuels and catalytic converters, are not being explored.

There are, however, innovation processes under way in the enforcement area where the development of new inspection procedures and the support for participative enforcement have the potential for relevant achievements.

E. Street dust emissions control

The Workshop determined that this non-established line is relevant to air quality in Santiago. In 1992, 800 km of urban paving were required to solve the problem of dust emissions from unpaved roads. In consequence paving investment was increased in 66 percent with respect to 1991 to US$15 million, allowing 200 km. per year to be paved. It was expected that the problem would be solved in four years. However, the generation of unpaved streets has outpaced the paving rate!

Dust is generated:

- in the city outskirts where new population settlements are established with incomplete access and distribution roads thus lowering the price of land,
- in deteriorated or partially paved streets inside the city limits, and
- as resuspended dust from sediment deposits in the streets caused by inadequate or non-existing rainwater drainage facilities.

MINVU (Housing and Urban Development Ministry), specifically SERVIU (Housing and Urban Development Service), appears as the institution with jurisdiction to regulate land development and the maintenance of road infrastructure but the results point to structural and financial deficiencies. Urbanization projects are undertaken without due consideration of paving requirements.

Stormwaters cause serious dust problems by carrying sediments from the surrounding mountain slopes and mud on unpaved streets. MOP (Ministry of Public Works) is executing the construction of a suitable stormwater system and there are local projects, in coordination with the municipalities.

Remedial action, for the critical Winter season, takes the form of a street washing program carried out by the municipalities with financial support from the Intendencia.

Quantitatively, both the intensity and extension of the problem are established since CONAMA R.M. has an emissions inventory and SERVIU has an inventory of unpaved streets.

The only innovation is an ongoing Participative Paving Program where the community and the municipalities join resources for financing the operation. SERPLAC contributes when resources are deemed insufficient.

In conclusion, there are specific actions undertaken by a host of different institutions to reduce dust emissions from unpaved streets. However, there is no institution in charge of a coherent plan for capturing the potential air quality improvements derived from this action line.

F. Transient source emissions control

This non-established action line is required to control several activities that originate air-pollutant emissions. For instance, construction of infrastructure (as in the case of the new Underground Railroad) produces dust as a result of both the actual earth movement operations and the subsequent transportation. The local impact on air quality is compounded with the emissions coming from slow moving traffic through detours established in residential areas. The general idea is to include

operation standards in the terms of reference for such works in order to minimize the impacts on air quality. Several control measures were suggested at the Workshop such as:

- the implementation of alternative routes previous to the beginning of the works,
- the installation of truck wheel-washers at the accesses to the construction site,
- the local intensification of the street washing program, and
- to require earth transporting trucks to be covered and to maintain adequate freeboard to avoid spills of material.

The sources cannot be considered either stationary or mobile; they are transient in the sense that their operation is not continuous in time. The emissions inventory would have to take this fact into account and be accordingly local in space and time. Quantification of the problem appears as the first step for solution; once the inventories are implemented, standards and the corresponding enforcement procedures could follow. There are no institutions in charge.

G. Domestic source emissions control

Non-established line whose management falls squarely into the responsibilities of MINSAL. Indoor pollution is a non-establihed particular line. There is evidence pointing to heating and cooking devices as relevant domestic emission sources, in particular for the urban poor that use charcoal, wood and kerosene burning appliances. In a recent study, Gil (1995) has established that the combined contamination resulting from smoking and air pollution that permeates from the streets in buildings of the downtown result in high levels of toxic particulates and CO. For large buildings (malls, office buildings, bus depots), deficiencies in ventilation and air-conditioning systems can pose bacterial or fungal contamination health hazards. Control in this area is the responsibility of MINVU.

In june 1993 by virtue of law decree 811 the Environmental Health Service established emission standards that resulted in the prohibition of the use of open hearth wood stoves in the Metropolitan Region. The market responded rapidly and today there are a great number of alternatives. However this flexibility is also a source of problems since many of the new technologies do not comply with the standard. The lack of adequate certification procedures is thus an important defficiency (see line I).

The control, of contaminants other than particulates may be an important innovation to be developed. In Mexico City, for example, defficiencies in gas stoves are an important source of No_x. Establishing an emissions inventory appears as a necessary innovation that is instrumental in the ensuing actions to build a control

system. Another innovation potential is related to the use of natural gas to replace kerosene and wood burning household devices.

H. Agricultural emissions control

Non-established line whose purpose is to improve the air quality in Santiago by controlling the emissions generated in agricultural activities in the areas surrounding the city. Quantifying the resulting atmospheric pollution share entails the following innovations:

- the establishment of an emissions inventory (to this end, CONAMA R.M. has already developed a preliminary inventory), and
- the development of a dispersion model in order to determine the pollutants contribution from this sector to the city quality indexes. CONAMA R.M. is currently working in a model to trace the source of all contaminants monitored in Santiago aiming at improving control efficiency by focusing and assigning priorities on an objective basis.

Interim actions have been directed to specific activities such as:

- Control of crop residues burning, seasonal activity that peaks at the beginning of the critical time for atmospheric contamination in Santiago. Restrictions enforcement is performed by SAG using terrestrial and aerial means. Control.is also exerted on the generation of a protective smoke screen against frost damage via combustion of used engine oil and tires.

- Control of fire based land clearing operations. CONAF is in charge of this control albeit not with air quality objectives.

Tillage could eventually be traced as a relevant source for particulates in Santiago, warranting restrictive measures whose sectoral support for enforcement might prove problematic given the critical situation of agriculture. A different approach for control calls for the study and possible adaptation of alternative agricultural practices already in use in other countries which minimize environmental impacts and have positive effects with regards to costs.

In conclusion the development of this line of action requires a joint institutional effort where the CONAMA R.M. expertise can be integrated with the AGRIMIN infrastructure to come out with a workable plan. The main challenge is to find a way to circumvent the sectors current economic crisis: additional restrictions to this sector based on environmental considerations do not seem politically viable.

I. Technical support for measurements and certification

This line aims at providing a suitable technical basis for the environmental quality assurance claims which are becoming common in global markets. Two specific action lines are already established; they cover quality control for stationary and mobile source emission measurements. These controls are required to supervise licensed auditors performance.

It is also necessary to make use of certification and registration of relevant operational characteristics, thus providing an efficient approach for enforcement of environmental standards. Registration of industrial equipment would follow a similar logic than the one used for new vehicles, but with the difference that the control is considered generic (not based on brand).

Reducing the possibility of corruption requires the assignment of legal liabilities to environmental quality claims, especially in the case of household appliances, aspects that should be covered under the Consumer Protection Act.

J. Non-regulated pollutants

For consistency non established line currently in an embrionary stage, that has two specific action lines: Air toxic control and foul smelling emissions control. The Environmental Framework Law requires that CONAMA establish a priority list of substances to be controlled in the following year. However, the only study aimed at regulating atmospheric toxic substances is currently being undertaken for arsenic from copper smelting plants.

MINSAL (Public Health Ministry) has legal competence for action in this area but it is exerted only in case of emergencies. Reactive control takes place under:

- accidental release of air toxics such as chlorine or ammonia, and
- complaints from the public regarding bad odors emitted by notorious offenders such as garbage dumps and slaughterhouses.

There are no systematic efforts to incorporate this line into its context of air quality. Developing an inventory should put the matter into perspective.

K. Episode control

This line of action provides a structured response to acute air pollution episodes. Its operating scope encompasses both stationary and mobile sources, where

a pre-defined set of activity restrictions is applied. The emergency status, which triggers the restrictive measures, is the consequence of surpassing a suspended particulate air quality index threshold (ICAP).

SESMA and MINTRATEL are empowered to define the restrictive measures; the Regional Director of CONAMA decides their timing. PROCEFF and police forces are in charge of the enforcement. Also, under emergency conditions, CONAF intensifies the control of banned activities such as burning crop residues and the generation of smoke for protection against frost damage (see line of action H).

The general setup has proven effective in keeping the air quality indexes below the critical threshold. However the need of a critical review of the cost-effectiveness of the measures has been identified, as there is concern in the private sector as to whether the high costs imposed by the restrictions are warranted and equitable.

Mitigating actions take the form of public campaigns for the restriction of physical activity during contamination episodes, including keeping children indoors on episode days. However, this latter recommendation has been criticized as the level of household air pollution might be even more damaging.

The following innovation potentialities have been detected:

- redefinition of the events that trigger the emergency status to encompass the surveillance for other contaminants together with the residence time, since health effects of reactive pollutants are related both to concentrations and residence time, and
- the development of predictive capacity for adverse dispersion conditions providing an "early warning" to episodes, allowing a proactive phasing in of activity restrictions. This calls for meteorological monitoring outside of the Santiago basin and the development of a dispersion model to incorporate these variables (see action line A). Activities in this line are currently being undertaken by the Universidad de Chile.

The line has a well defined institutional support. The evolution from reactive to proactive action -i.e., taking preventive measures- is definitely linked to the realization of the two potentialities identified above.

L. Promotion of energy quality

Non-established line in search of institutional infrastructure to harbor and foster the development of *environmentally efficient* energy use. The distinction is relevant since there are both private and public sector efforts towards energy efficiency that

do not explicitly have air quality objectives; and it will become more relevant with the imminent introduction of natural gas which will make feasible the development of energy intensive activities. Indiscriminate gas usage raises the possibility of a shift in the existing pollutant levels towards highly reactive oxidants, tropospheric ozone being one of the more conspicuous, as a result of high NOx emissions. At the same time, gas based state-of-the-art technologies have contaminant reduction capabilities well beyond the strictest standards. Setting the proper course calls for establishing an ad-hoc, instrumental institutional system to control the transition, incorporating environmental considerations in incentives and regulations in order to achieve the full realization of the air quality improvement potentialities.

The introduction of gas determines the main innovation potentiality for this line and its consequences for the air quality of Santiago are crucial.

Earlier efforts in other fuels led ENAP to the reduction of sulphur and ash content in diesel and fuel-oils but their outcome regarding air quality may be considered a design externality since the objective was the protection of fuel injection mechanisms. Private fuel distribution companies introduced additives in order to improve combustion in heat generating devices which, in some cases, allowed meeting emission standards without further modification. Again this is another example of a serendipitous spillover while searching for economical efficiency.

CNE (National Energy Commission) has evaluated the introduction of alternative fuels in urban mass transit in Santiago with an explicit air quality objective. The study shows the feasibility for conversion to natural gas even from a strictly private point of view.

The potentiality for air quality improvement in this area is identified; the institutional mechanism for its realization awaits for development.

M. Transport system

Santiago's transport system covers a set of seven specific lines of action in the city's action map for air quality. At a more disaggregated level -included as a special action map given the detail of the Workshop's work on transport- it involves 26 lines of action of the second degree of specificity (see next page). As may be seen, only three of the seven lines are fully established: Structurig and Access Roads (M-1), Rapid Mass Trsnsport System (M-3) and Bus System (M-4); at the disaggregated level only 9 of the 26 second-degree lines are established.

Action map: (*)

TRANSPORT SYSTEM OF SANTIAGO

Key: **UPPER CASE** - **established line of action**
lower case: - **non-established line of action**

M-1 STRUCTURING AND ACCESS ROADS
- M-11 CONSTRUCTION OF ACCESS ROADS
- M-12 CONSTRUCTION OF STRUCTURING ROADS

M-2 Traffic management
- M-21 [INTEGRATED OPERATION OF TRAFFIC LIGHTS]
- M-22 Operation and maintenance of streets
- M-23 Road segregation
- M-24 Regulation of car circulation
- M-25 Parking policy

M-3 RAPID MASS TRANSIT SYSTEM
- M-32 [Light rail transit]
- M-33 [Pre-metro systems]

M-4 BUS SYSTEM
- M-41 ORGANIZATION OF BUS LINES INTO COMPANIES
- M-42 REGULATION OF BUS CIRCULATION
- M-43 REGULATION OF TECHNICAL CHARACTERISTICS
- M-44 Bus terminals
- M-45 BUS STOCK POLICY

M-5 Taxi fleet size and use policies
- M-51 Regulation of circulation of basic taxis
- M-52 REGULATION OF CIRCULATION OF COLLECTIVE TAXIS
- M-53 [Basic taxi fleet policy]
- M-54 Collective taxi fleet policy

M-6 Disincentives for private car use
- M-61 Road pricing
- M-62 [Car pooling]

M-7 Inter-modal and alternative transport modes
- M-71 Metro-bus integration
- M-72 REGULATION OF BUS CIRCULATION
- M-73 REGULATION OF TECHNICAL CHARACTERISTICS
- M-74 Bus terminals
- M-75 BUS STOCK POLICY

(*)This action map was prepared by the project team on the basis of the Workshop's material for the transport System line of action. Lines in square brackets [...] have been added to fill voids.

This Action Map belongs to project report "A Management System for Air Quality in Santiago", by Dr. Alfredo del Valle (The Innovative Development Institute, Santiago, Chile) and Dr. Raúl O'Ryan (Department of Industrial Engineering, Universidad de Chile). Santiago, Chile, September 1995.

For Structuring and Access Roads in Santiago (M-1) there are institutional capacities at the Ministries of Public Works (MOP) and Housing and Urbanism (MINVU), the Urban Transport Commission (SECTRA) and the Municipalities; of the latter, they are only exercised by the ones having resource surplusses and thus techynical and financial capacities: Las Condes, Providencia, Santiago and Vitacura. The management instruments utilized are specific road projects generated separately and SECTRA's quantitative model ESTRAUS. In this line there are two innovation processes under way: MOP's plan for urban auctioning and several inter-municipal projects. By way of a general evaluation the following may be stated: (1) a common and integrated vision for these roads is still missing among its actors; (2) evaluation methodologies have still not sufficiently considered the variety of impacts on air quality these roads have; and (3) the innovation capacity demonstrated shows that there is capacity in the city for facing these challenges adequately.

The Rapid Mass Transit System (M-3) is fully established in Santiago, and its institutional and technical capacities are installed at the state-owned company Metro S.A. which operates the underground raiboard There are also institutional capacities at the State Railways Company. The main current investment project is Line Five, to the south of Santiago. As an innovation project, the recovery with underground raiboard standards of old urban railways currently in disuse is under evaluation; a mono-rail was also reviewed, after a municipal initiative from Las Condes, but it resulted non-profitable. As a general evaluation of this line, which is particularly interesting for air quality it may be stated: (1) its actual management takes place at the ministerial level, rather than regional level, in view of the large investment volumes involved; (2) there is no mandatory integration with the other transport management processes; and (3) there is no policy linking it to segregated ways, which could perform as pre-underground raboards.

The basic institutional capacity for managing the Bus System (M-4) is installed at the Metropolitan Secretariat (SEREMI) of the Transport Ministry. There are also institutional capacities at MINVU, dealing with terminals, and at Municipalities, dealing with terminals and circulation. The fundamental management instrument is the conditioned auctioning of rights to use ways, which establishes technical and organizational conditions for bus lines, and regulates circulation (this instrument regulates jointly lines M-41, M-42, M-43 and M-45). Other instruments regulate technical characteristics and operating conditions of vehicles. Regarding innovation processes, the introduction of electronic money collectors is under evaluation and it is foreseen to work on terminals policy, optimization of the auctioned system and labor relationships between bus owners and drivers. As a general evaluation it should be stated that this is a recent line of action in the city, which has been able to become fully established.

The other four specific lines of Santiago's Transport System are still not fully established, though within them two second-degree lines are established (M-21: Integrated operation of traffic lights and M-52: Regulation of circulation of

collective taxis). The large number of institutions involved in these lines should be noticed: several internal units of three Ministries at national and regional levels, 32 Municipalities, Carabineros, SECTRA and Metro S.A. There is a considerable number of innovations under study in these lines: coordination of traffic lights, differentiation of bus stops, experimental segregated way, parking policy, technical support to municipalities, road pricing and modal interchange stations for freight. All these innovations are coming from the central and regional levels, however, which points to the very scarce technical, and almost negligible innovation capacity of the Municipalities, with the four exceptions already made.

As regards this Transport System as a whole, it should be highlighted that all three established lines of action have a directly favourable incidence on air quality, both by reducing congestion (roads and buses) and by substituting polluting trips (underground raiboad). Nevertheless, the Workshop did not hesitate in rating the general line of action (M) as a non-established one. On the one hand, everything is sectoralized here, without a unifying or even coincident criteria. On the other, transport has strong interactions with the city's growth modalities, which are scarcely outlined in the debates about Santiago and are not yet expressed in effective management instruments. We should point out, however, that there are some integration factors that are under way: the work towards the formulation of a Transport Master Plan that is being carried out by SECTRA, the joint work with municipalities being done by the Transport SEREMI, and the establishment of a Regional Committee for Infrastructure and Territorial Management (CRIOT) within the Regional Government. Policy makers are indeed aware that something must be done to integrate management processes, and are receptive to ideas of integration. This is a favourable climate for the explicit and effective incorporation of air quality critera.

N. Management of the bio-physical environment

This is a non-established line that covers aspects related to improving the air quality of Santiago via changes geared at reducing the negative influence of the physical setting of the city in the generation and dispersion of contaminants. The general approach aims at reducing the level of suspended particulates originating in fugitive emissions from the deforested areas surrounding Santiago.

Only two component lines were considered as established in the Workshop. One, called "green lungs", is aimed at providing suitable vegetation cover in intra-city areas. The other points to preventing the migration of air and waterborne particulate from the mountain slopes around the city through forestation. At present these action lines have a weak link with air quality, as their observed performance suggests ornamental objectives for the former and the other is included in a general plan to stop the desertification, where the soil productivity loss for Santiago has a low priority.

The issues related to erosion control and watershed management are dealt with under the perspective of protection of water resources; air quality is considered as a minor concern. There are, however, innovation potentialities which could become environmentally relevant under proper orientation:

- the search for a preferably perennial vegetation cover able to withstand and inactivate air contaminants and that does not contribute air pollutants such as natural VOC's or pollen,
- taking advantage of the new approach for soil protection embodied in the modifications of DL 701,
- legislative action to modify the current Water Act incorporating air quality considerations such as silt control, and
- a project for integral management of the Mapocho river basin with the aim of controlling flooding episodes that are a source of resuspended particulates during the critical Winter season.

The knowledge base for the exploration of potentialities is reasonably developed; further know-how could be gathered from actual experiences in other countries. However there is no conscience as to the relation between these activities and improving air quality in Santiago.

O. Socio-spatial management

The Workshop called Socio-Spatial Management a group of nine specific lines of action, which are related with managing the relationships between Santiago's population and the space it inhabits. Three of them were regarded as established: Territorial Management (O-3), Industrial Location (O-6) and Densification Programs (O-9).

Territorial Management is carried out in Santiago through institutional capacities that have been based traditionally at the Ministry of Housing and Urban Development (MINVU) and its Regional Secretariat (SEREMI), the Housing and Urban Development Service (SERVIU), and the Municipalities. There is also involvement of the Ministry of Planning ad Cooperation (MIDEPLAN) and the Undersecretariat of Regional and Administrative Development of the Ministry of the Interior (SUBDERE). As will be mentioned at the end of the section, the Regional Government is becoming a new actor in this line of action. The mentioned institutional capacities are expressed in a series of management instruments, both general and specific, geared to regulating the conditions of use of space: metropolitan land-use ("regulatory") plan; municipal land-use plans; sectional land-use plans; urban limits; urban development permits; building permits; and authorizations for "harmonic developments". Technical capacities are sufficient for the metropolitan plan, are under development for the municipal and sectional plans, and are insufficient for the specific instruments that are administered by

municipalities. Some innovation iniciatives in this area are under way, addressed to standardizing and simplifying building permits, establishing bases for formulating urban development plans and extending land-use plans to rural areas..

The general evaluation of this line of action is that in practice there has existed no effective territorial management with a long-term view. MINVU is only able to set norms, but not to enforce them. Its instruments can only recognize trends, but can not alter or direct them. Barring exceptions, the ones who have effectively dictated the conditions of land use in Santiago have been the real estate development companies. Among the reasons for this, the following should be mentioned: (1) several public agencies have overlapping mandates in this areas: MINVU, MIDEPLAN, SUBDERE and other; (2) it has not been possible to bring effectively to practice MINVU's instrument "urban development plan", which would act upon development processes in space and not only upon conditions of use of space; (3) there has existed a severe lack of stability among professionals, of training and of adequate compensation levels, in the public agencies in charge of these responsibilities.

Regarding Industrial Location (O-6), institutional capacities exist at the same entities as for Territorial Management, excepting SERVIU and adding the Metropolitan Health Service of the Environment (SESMA) of the Health Ministry. Its instruments are also the same, excepting the "harmonic developments", and adding the environmental rating of industries that SESMA can make as *inoffensive, annoying, polluting* or *dangerous*. As innovation processes, the mandatory relocation of industries not qualifying as inoffensive is already under way, and the broadening of classification criteria for annoying industries is under study, to include a category for *negative urban impact*. As a general evaluation, in this matter: (1) the Metropolitan Land-use Plan includes criteria linked to air quality, such as favouring locations which attract population and avoid trips, and locations with the appropriate wind directions; and (2) the effectiveness of new instruments is being tested, with open questions about the required enforcement capacities.

The Densification Programs (O-9) are managed on the basis of institutional capacities based at the Housing and Urban Development SEREMI, the Metropolitan SERVIU and the Municipalities. The scope of application of these capacities is the deteriorated urban areas which have good infrastructure. Specific instruments for these purposes are: the declaration of "renewal zone", which gives rise to an escalation in municipal taxes; and the urban renewal subsidies. As innovation process, the declaration of "metropolitan interest area" is being established, for areas larger than 1 ha, which will only allow 30 percent use for dwellings. As evaluation, very scarce use has been made to date of the declaration of renewal zone; the main instrument in use is the subsidy.

We should finally refer to the effects on Socio-Spatial Management that is having the recent establishment of the Regional Government of the Metropolitan

Region, which as in all regions started formal operation as recently as 1993. The Regional Government has broadened the political significance of territorial management, and understands it as a line of action that exceeds the sectoral scope and must be undertakern at a higher level. For its management it has brought into operation a Regional Committee for Infrastructure and Territorial Management (CRIOT), which has started working with some concrete tasks on other environment-related matters. The existence of this regional orientation is auspicious for integrated management of air quality in the city.

P. Education and communications

Non-established line, whose purpose is to raise awareness of citizens about environmental issues. As such, is seeks to establish a cultural basis by means of changes in formal education and by introducing the issues in the day-to-day decisions by promoting specialized journalism and educational activities by NGOs.

In 1992 the Ministry of Education (MINEDUC) included environmental issues into formal education through the Program for Environmental and Ecoloigical Education. Teaching material was prepared for preparatory and high school levels, and projects related to the environment were sponsored in schools of the city. The development of the Program for Improvement of Equity and Quality in Education (MECE) has introduced changes in curriculum. These efforts by MINEDUC have been carried out in cooperation with other government institutions like the National Energy Commission, CONAMA, National Forest Commission and also with NGOs like TEKHNE.

It is expected that these efforts will result in cultural changes favourable to the protection of the environment. However, they are sporadic and incomplete, and there is no specific institution in charge of this line.

6. MANAGING AIR QUALITY: A PROPOSAL FOR ACTION

The question raised in this chapter,"what needs to be done?", will be asked in as realistic terms as possible. It would be useless to make here some "technical" statements about what needs to be done, and then to assume that it is the duty of the "politicians" to build up the feasibility that such a proposal requires. In our view the technical-political dichotomy is often the excuse of the technicians for not dealing with social problems in their entirety, and for simplifying them down to the capacity of their models. In keeping with our methodology, we will try to handle this question in its whole complexity, without simplifying it.

For these purposes the chapter has three sections. The first one states the basic characteristics that in our view the air quality management system should have. The

second section makes an explicit description of the institutional constraints that set the stage for the proposed action. And the final one presents the authors' proposal for building up this management system in the present political and institutional conditions.

6.1. The required management system: Basic characteristics

In order to be effective, the air quality management system of Santiago should have the following basic characteristics:

- **Mission: Protecting Santiago's air quality**. The city of Santiago should confer upon this system the mandate and responsibility of protecting the city's air quality over the long term. This would imply reaching and maintaining air quality standards for criteria pollutants and applying emission standards for toxic substances.

- **Scope: The whole action map**. In order to fulfill this mission the management system would work along the 16 basic and the 92 specific lines of action included in Santiago's action map. The relevant domain to be protected is the metropolis of Santiago, which requires action covering the whole relevant airshed.

- **Operations**: Supervising all established lines of action. The management system would not necessarily operate the specific lines of action contained in the map. However, it would supervise all of them from the air quality perspective. This requires: (a) that it has available institutional capacity, i.e., effective instruments to influence the relevant operations in those lines of action and capacity for effective integration of sectoral work; and (b) availability of technical capacity to operate such instruments through consolidated and stable teams.

- **Development**: Establishing and strengthening lines of action. The management system would promote innovation to both strengthen established lines of action and implement lines that are still not established. This requires: (a) identifying and evaluating potentialities for improving air quality in all lines of action; and (b) supporting the implementation of specific projects which materialize such potentialities.

- **Financing**: Autonomous and long term. The management system and many of the lines of action would not be more than good intentions unless they have assurance of financing for the long term. There are currently established lines that presently run the risk of disappearing for lack of stable funds.

6.2. Current institutional constraints

In order to be effective, work towards building up an air quality management system in Santiago should be designed to operate within the following institutional and political constraints:

- **A "small state":** The proliferation of bureaucracies is under severe surveillance in Chile. To the extent possible, the management system should be based on existing institutions.

- **No metropolitan government yet:** The action map has three highly significant lines of action (M, N and O) that are not established and that ought to be managed at the metropolitan level in order to be effective. This reaffirms the need to examine the convenience of establishing a metropolitan government in Santiago, which has been proposed both by some researchers[17] and politicians, though there is no open debate on the subject. No assumption about such a government is made in this proposal.

- **Central, regional and municipal government involvement:** Management processes taking place in Santiago that are relevant to each of the 92 specific lines of action in the map correspond to one or more of three types of government: central (Ministries), regional (Intendente, SEREMIs, Metropolitan CONAMA) and municipal (Mayors). Consequently, all three levels should be involved in the management system.

- **Operational capacity distributed among several actors:** There is operational capacity in areas relevant to air quality management in Chile at the Ministries of the central government, a few Municipalities, several Universities and technological institutes, and the private sector. All this capacity should be made use of by the air quality management system, particularly through outsourcing mechanisms.

- **Unlikely financing from international cooperation:** International cooperation resources have been highly significant for building up what exists regarding air quality management in Santiago. However, only limited amounts of international funds can be expected in the future. This will demand a stronger commitment from the government as well as the generation of funds from other sources, preferably linked to air quality related actions.

[17] One of the authors has done research on the subject. See Del Valle (1991).

6.3. A concrete action proposal

The proposal to be made in this section is not a proposal for a new institution in Santiago. This will rather be a proposal for undertaking a process. More specifically, we propose to involve all relevant actors of air quality in Santiago into a participative process that would establish concrete bases for building up the air quality management system that is required. Owing to the natural limitations of a project like this one, the description will only be conceptual and qualitative.

The following elements make up this proposal:

- **Purpose - identification and evaluation of potentialities:** This process would be focused initially upon the identification of the potentialities for improving air quality that may exist in Santiago. Potentialities would offer a realistic vision of the future attainable by the city in this field, while opening a path to construct it. Additionally they would show which resources are available in the city and its related institutions, since they always possess, attract or generate resources of their own. Finally, the process of discovering these potentialities would generate the consensus and the commitment among the relevant actors that are required for their effective implementation.

- **Structure - an autonomous project:** The simplest way for carrying out this process is by means of an autonomous project, which would not be a part of any of the regular management activities for air quality that are currently in operation. According to experience in similar processes[18], this procedure would simplify communications, prevent interference with day-to-day activities and especially avoid confusions with formal mandates regarding plans and other instruments.

- **Conveners - a multi-actor Council:** Since there is no institution having a mandate covering the whole scope of the action map, the overall guidance of this project would be provided by a Council of Conveners. This Council would be formed by Ministers, Congressmen, other high government officers (Intendente, CONAMA, COREMA, etc.), Mayors, private sector representatives, academic authorities, NGOs, etc. The Council would invite participants, oversee the whole process and assure its financing.

- **Participants - all relevant actors:** In order to assure a sufficient number and diversity of contributors in each line of action, the invitation to participate should be wide and open. Our experience shows that people's willingness to participate in processes like this is very high, since they are invited to build a future for a system they are committed to. Moreover, the interactive and

[18] See note 12 above.

action-oriented methodology applied assures that contributions are relevant, updated and complete.[19]

- **Working outline - the action map:** According to the methodology, work would be organized in 16 parallel working groups, one per line of action. Participants would sign up freely in the group of their preference and would be free to participate in as many groups as they wished. Each group would identify potentialities in its line of action, and would be informed of progress being made by the other groups.

The concrete output of this process, in its initial phase, would be twofold: (a) a consensual set of profiles of potentialities, including for each a basic technical description, an action proposal and an identification of the actors who should promote the corresponding innovations; and (b) the commitment of the participants to promote and undertake these tasks in their particular spheres. On these bases the Conveners would be prepared to consider a specific institutional proposal for the air quality management system, and/or to proceed to the technical evaluation of the potentialities identified.

[19] In addition, this procedure has comparatively a much lower cost than conventional work with experts in each line of action, plus the added value of interaction among actors. Notice that participants contribute a large amount of expert-hours without charging for them, since they also obtain a significant learning benefit.

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